Deliverable D6.1-19b_revision

“Intermediate Publishable Report”

Date of issue

02 June 2022

Name of Author(s) : Werner Haase

Organisation: CFD Software- Entwicklungs- und Forschungsgesellschaft mbH (**CFDB**)

Wolzogenstrasse 4

14163 Berlin, Germany

Email: whac@haa.se
werner.haase@cfd-berlin.com

Grant Agreement 861438

COPYRIGHT AND CONFIDENTIALITY NOTICE

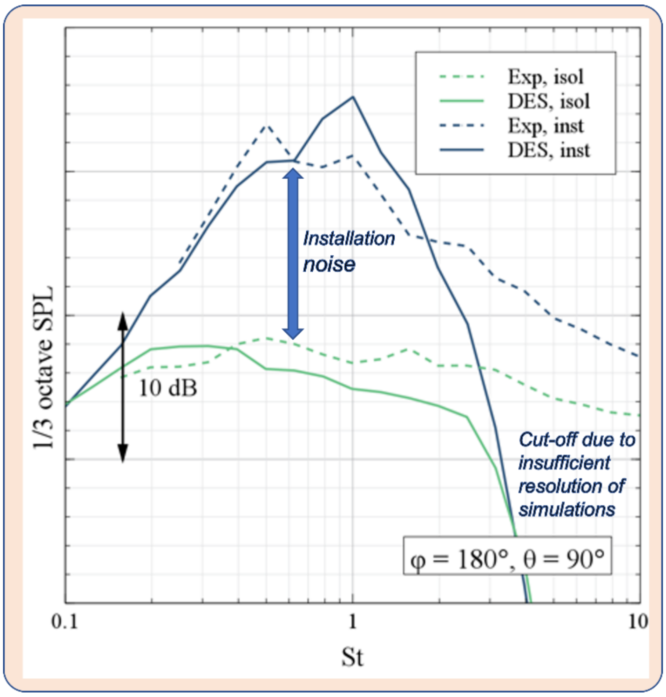
The work described in this document was performed as part of the DJINN project (Decrease Jet Installation Noise), which is funded by the European Union under the Grant Agreement **GA 861438**.

The EU DJINN project is a collaborative effort between CFD-Berlin (coordinator), Airbus SAS, Dassault Aviation, Safran Aircraft Engines, Rolls-Royce Deutschland, ONERA, DLR, University of Southampton, CERFACS, Imperial College London, von Karman Institute, CNRS, and Queen Mary University of London.

The opinions, findings and conclusions expressed in this report are those of all partners and do not necessarily reflect those of the European Commission.

The following information is equivalent to the information provided on the 'Reasearch-and-Innovation' Portal of the Commission:

External aircraft noise has become an important political issue. With a 5% estimated annual growth rate of air traffic volume, substantial reductions of aircraft noise are required to keep air travel environmentally sustainable. as an example, the noise radiation of a turbofan is substantially increased when installed under the wing of an aircraft. The problem is even more aggravated by the development of engines with increasingly large jet diameters and smaller jet speeds, which are necessary to improve the propulsive efficiency of the jet and reduce the fuel burn of the aircraft. Hence, the installation noise sources in the low-frequency range with Strouhal numbers between 0.2 and 2 increase the noise emission by up to 14 dB for an observer position directly below the aircraft, see figure below.



The goal of the DJINN project is to push noise-reduction technologies to a Technology Readiness Level (TRL) between 4 and 5. The technologies to be developed will enable an industrial installation (Entry-Into-Service) by 2030-2035. The results and new/advanced CFD methods to be obtained in the DJINN project will lead to improved simulation platforms by the partners.

Improved aero-acoustic predictions of turbo-engines will serve the environment directly and will consequently lead to greener aircraft offering reduced noise levels together with improved fuel consumption. Thus, the project offers a significant step-change and improvement for ensuring a favourable environment and will achieve considerable relief for citizens living in the vicinity of large airports.

Amongst the goals mentioned above, the quantitative, overall objectives can be summarised as:

- Increase the frequency range of simulations up to Strouhal numbers of 10, whilst maintaining affordability and ability to capture the complex geometries representing the two aircraft configurations selected.
- Predict under-wing jet-airframe interaction noise to within 1 dB accuracy.

- Demonstrate a reduction of jet-airframe interaction noise peak level at low frequencies by 5 dB by designs and technologies to be investigated and verify at aircraft level that the combination of integrative designs and technologies mitigate the risks associated with jet-airframe in-flight interaction noise.
- Reduce the turn-around time of high-order (CFD) approaches by a factor of 5, using h-p refinement techniques for approaches such as Spectral Difference Methods (SDM) (mesh + simulation + post-processing).
- Evaluate innovative high-fidelity simulation-method components (accelerators, alternatives to FWH, improved numerical schemes) and reduce turn-around times significantly – in the case of GPU usage by an additional (estimated) factor greater than 5.
- Reduce design times and costs by 25% compared to large-scale testing.

Work performed since the start of the DJINN project (1 June 2020) is exhibited in the mid-term report, being a major part of the mid-term reporting. This report contains all relevant achievements and furthermore provides the status for deliverables and milestones.

A most prominent ambition is to achieve ‘low-noise design capabilities’, suitable for under-wing and rear-fuselage mounted engine installations including tail-plane optimisation. Hence, the goal is to demonstrate noise reduction due to wing-trailing-edge modifications and/or nozzle-based technologies such as jet vectoring, leading to their introduction into the real-aircraft design. In addition to high-fidelity simulation tools, a further ambition is to develop a low-cost simulation methodology with turn-over/wall-clock times at least three orders of magnitude faster than scale resolving simulation.

A second item is an advanced experimental-numerical interaction and physical understanding, leading to the validation of low-noise technologies on different aircraft platforms with the potential to reduce community noise and to eliminate noise risks associated with future installation concepts and more efficient engines. This combines high-tech experimental methods with accurate numerical simulations to steer the development of noise reduction technologies - prior to expensive acoustic wind tunnel tests.

Going beyond the state of the art means to develop numerical multi-physics (CFD-CAA) methods enabling the integration of acoustic restraints early in the design process of new engines and configuration concepts (Design-to-noise). The use of turbulence-resolving simulations will advance the understanding of complex noise source phenomena and will lead to even more innovative noise-reduction ideas. Further progress is expected - and has been partially achieved - for shortening wall-clock times for CFD simulations by a highly scalable code (structure) to be applicable to massive parallel computations, and a proof of concept that GPU-based HRLMs is turned out, being more than 5 times faster based on modest computer requirements. The aim of the DJINN-project work is to move from large-scale testing to HiFi-CFD for high-TRL demonstration.

Based on the information given above, potential impacts can now be summarised, keeping the ‘Flightpath 2050’ goals in mind, with CO2 emissions per passenger kilometre to be reduced by 75%, NOx by 90%, and perceived noise by 65% by 2050, relative to the year 2000:

1. Significantly reduced A/C design cycle costs and time by improving the numerical simulation tools
2. Establish and validate new NRT (noise reduction) technologies as a basis for noise-reduction technologies on both the engine and airframe sides.
3. Advanced multi-disciplinary and collaborative capabilities to enable multi-disciplinary and multi-objective designs in industry and research
4. Exploitation and technology transfer of high-fidelity methods and associated simulation processes to the OEM partners

5. Increase the European innovation potential in Aeronautics by an integrated collaboration between industry, including SMEs and research partners
6. Enhancing innovation capacity
7. Strengthening competitiveness and growth of companies by providing (more) reliable CFD approaches resulting in user-friendly design environments with less user intervention for CFD simulations
8. New market opportunities by making complex industrial simulations feasible and reducing design cycles and costs, thus “time-to-market”
9. Routinely run HRLM/LES simulations of a complete aircraft in landing configuration for aero-acoustic applications with short turnaround times, say around 24 hours
10. Impact on the environment by improved aero-acoustic predictions of turbo-engines, serving the environment directly leading to greener aircraft offering reduced noise levels together with improved fuel consumption.

The DJINN website can be visited on djinn.online